HART CROWSER & associates inc.
GEOTECHNICAL & HYDROGEOLOGIC CONSULTANTS

P-1984(Revised)

December 21, 1983

Lilyblad Petroleum, Inc.
2244 Port of Tacoma Road
Tacoma, Washington 98401

Attn: Mr. Greg Allen

Re: Revised Hydrogeologic Study
"Poligen" Site
Port of Tacoma

Dear Mr. Allen:

This letter presents our revised proposed scope of work and estimated cost for the referenced project. We understand the purpose of our work is to evaluate the hydrogeoloigc and water quality conditions beneath the site, so that a ground water monitoring program may be implemented. Our revised proposal is based on information provided to us by you and Pat Wicks, which includes the general requirements of the Department of Ecology (DOE).

We anticipate the geology of the site to consist of a variable thickness of dredged fill which overlies a natural silt/clay stratum which in turn overlies a natural sand stratum. Typically the silt/clay stratum acts as an aquitard (restricts the vertical flow of water or contaminants). We expect the top of the silt/clay stratum lies at a depth of 10 to 20 feet below the ground surface, and that the top of the underlying sand stratum lies at a depth of 30 to 40 feet below the ground surface.

The regional ground water flow direction in the Port of Tacoma is generally towards Puget Sound. However, local flow directions can be modified by the presence of the waterways (Hylebos and Blair), subsurface pipe bedding and drainage ditches. Variations to expected (based upon topography and position of surface waters) ground water flow directions are especially common in the surficial dredge fill soils in the Port area.

To assist you in meeting the DOE requirements, we propose to complete the following tasks:

TASK 1 - Drill and Install Observation Wells

We propose to drill and sample three borings to a maximum depth of 25 feet at locations A, B, and C shown on Figure 1 (These are the locations

suggested by the Department of Ecology). Drilling would be accomplished using a hollow-stem auger and soil samples would be obtained using a 2-1/2-inch split-spoon sampler. Soil samples would be placed in glass jars. Drilling would be conducted until 2 to 3 feet of the silt/clay stratum is encountered or until a depth of 25 feet is reached, whichever comes first. The borings would be backfilled with grout/bentonite to the level of the approximate top of the silt/clay stratum. The borings would then be converted into monitoring wells by telescoping through the center of the auger 2-inch PVC screen and riser pipe, placing a sand pack adjacent to the screen and removing the auger. The wells would be finished with locked metal monuments.

The drilling tools would be steam cleaned between holes. The split-spoon sampler would be rinsed with clean tap water between sampling runs. Before leaving the site the drilling rig tools and sampling equipment would be steam cleaned.

After the wells are installed they would be developed using compressed air. The water that is air lifted from the wells would be directed into drums provided by Lilyblad for disposal after the results of the ground water chemical analyses are obtained.

During drilling, an experienced geologist would be on-site to describe the soil samples, and observe the drilling operation and well installation. A geologic log would be prepared based upon these observations.

As requested by the DOE, we have included the cost for a fourth deep well. We anticipate this well would be drilled to up to 40 feet to penetrate a natural sand aquifer below the silt/clay layer. This well would be drilled and finished in a similar fashion to that described above, except for the backfilling of the boring below the screen. For the deep boring, a grout seal would be placed above the screen, adjacent to the silt/clay stratum to minimize the possibility of vertical migration of ground water in the borehole.

TASK 2 - Make Field Measurements

Three to four days after the wells have been installed we would measure water levels using a chalked tape. We would also survey the relative well head elevations. A series of water levels would also be taken to assess the effects of tides on the water table. The water tables would be adjusted to a common datum and the general direction of ground water flow would be assessed. This evaluation would also consider the possible effects of drainage ditches in the area.

It should be noted that under certain conditions (i.e., relatively simple flow patterns) three borings may be adequate to evaluate the average ground water flow direction. We would evaluate the data as to reliability and recommend additional wells if appropriate.

TASK 3 - Collect Water Samples and Complete Analyses

Three ground water samples would be collected from the wells and analyzed for the following:

pH
Temperature
Conductivity
Cyanide (Total and free)
Total Heavy Metals:
- Arsenic
- Lead
- Cadmium
- Chromium (Total and Hexavalent)
- Nickel

Phenol
Total Oil and Grease
Polynuclear Aromatics (PNA)
TOX
Trichloroethane
Tetrachloroethylene
Xylene
Tolune
Methylene Choride

Water samples would be obtained using a stainless steel/teflon, nitrogen gas displacement pump. A separate pump and tubing would be used for each hole. Prior to sampling, we would attempt to remove at least three casing volumes of water. Where this is not possible, the well will be excavated at least once before obtaining a sample. The sample will be placed in containers as provided by Am-Test, packed in ice and transported to the laboratory. We will notify DOE at least three days prior to sampling so that sample splits may be obtained by the DOE, if desired. The proposed analytical parameters, methods, and detection limits are listed on the attached Am-Test letter, dated December 16, 1983.

TASK 4 - Reduce and Analyze Data, and Prepare Report

The purpose of Task 4 is to design a monitoring program and prepare a report that can be submitted to the DOE for review and comment. This report will include:

1) Site Plan showing well locations.
2) Geologic logs and well construction features.
3) Geologic cross section.
4) Evaluation of ground water flow direction.
5) Results of water quality analyses.
6) Recommendations for ground water monitoring.
7) Recommendations for additional study (if warranted).

TASK 5 - Attend Meetings

We have included the cost for attending two meetings in Tacoma. We would be available to attend additional meetings as requested. These would be billed on a time and materials basis.

We estimate the cost of the above work to be approximately $12,000 in general accordance with the following breakdown:

Task 1 - Drill and Install Observation Wells

THREE 25 FEET DEEP WELLS

Hart-Crowser

Associate Hydrogeologist (est. 2 hrs @ $60/hr)	$ 120	
Staff Geologist (est. 20 hrs @ $40/hr)	800	
Travel	60	
Equipment Rental (Compressor)	50	
SUBTOTAL	$1,030	

Subcontracting

Mobilization	$ 100	
Drill and Sample at 5 feet intervals (est. 75 feet @ $9/ft)	675	
Extra Sampling (est. 15 @ $12.50 each)	190	
Well Installation and Steam Cleaning (est. 6 hrs @ $75/hr)	450	
Steam Cleaner Rental	175	
Materials (PVC, grout, sand monuments)	425	
Sales Tax (8% of $2,015)	160	
Hart-Crowser Handling Fee (12% of $2,175)	260	
SUBTOTAL	$2,435	
ESTIMATED TASK 1 TOTAL		$ 3,465

Task 2 - Field Measurements

(Make Water Level Measurements and Survey Relative Well Head Elevations)

Hart-Crowser

Associate Hydrogeologist (est. 1 hr @ $60/hr)	$ 60	
Staff Geologist (est. 18 hrs @ $40/hr)	720	
Travel	100	
ESTIMATED TASK 2 TOTAL		$ 880

Task 3 - Water Sampling and Analyses

Hart-Crowser

Associate Hydrogeologist (est. 2 hrs @ $60/hr)	$ 120	
Staff Geologist (est. 10 hrs @ $40/hr)	400	
Travel	20	
Pump Rental (Three Pumps)	200	
SUBTOTAL	$ 740	
Subcontracting		
Water Quality Analyses (est. 3 spl. @ $726/spl.)	$ 2,178	
Hart-Crowser Handling Fee (12% of $2,178)	260	
SUBTOTAL	$ 2,438	
ESTIMATED TASK 3 TOTAL		$ 3,178

Task 4 - Reduce and Analyze Data, Prepare Report

Principal Geologist (est. 2 hrs @ $75/hr)	$ 150	
Associate Hydrogeologist (est. 20 hrs @ $60/hr)	1,200	
Senior Staff Hydrogeologist (est. 30 hrs @ $45/hr)	1,350	
Staff Geologist (est. 8 hrs @ $40/hr)	320	
Drafting (est. 8 hrs @ $35/hr)	280	
Clerical (est. 6 hrs @ $25/hr)	150	
Reproduction	100	
ESTIMATED TOTAL FOR TASK 4		$ 3,550

Task 5 - Meetings

Associate Hydrogeologist (est. 15hrs @ $60/hr)	$ 900	
Travel	40	
ESTIMATED TOTAL FOR TASK 5		$ 940
ESTIMATED PROJECT TOTAL (w/o deep boring or soil analyses)		$12,013

We estimate the additional cost to drill a deep (40') boring, if required, would be approximately $1,700 as follows:

ONE 40 FEET DEEP WELL

Hart-Crowser

Associate Hydrogeologist (est. 1 hr @ $60/hr)	$ 60	
Staff Geologist (est. 10 hrs @ $40/hr)	400	
Travel	20	
Equipment Rental	25	
SUBTOTAL	$ 505	

Subcontracting

Mobilization	$ 100	
Drilling and Sampling at 5 feet intervals (est. 40 feet @ $9/ft)	360	
Well Installation and Steam Cleaning (est. 2 hrs @ $75/hr)	150	
Extra Sampling (est. 8 spl. @ $12.50 each)	100	
Steam Cleaner Rental	50	
Materials (PVC, grout, sand monuments)	240	
Sales Tax (8% of $1,000)	80	
Hart-Crowser Handling Fee (12% of $1,080)	130	
SUBTOTAL	$ 1,210	
Estimate Additional Cost for Deep Boring		$ 1,715

The cost for soil analyses would be approximately $825 per sample, as outlined in the attached AmTest letter and including our 12% handling fee.

TERMS AND CONDITIONS

In the event that unexpected conditions are encountered which appear to require additional study, we would bring them to your attention and seek your approval for any added expenditures. All of our charges are invoiced on a time and materials basis predicated upon the enclosed fee schedule which is subject to subcontract and inflationary change. The terms and conditions of the fee schedule are incorporated into our agreement with you and by your authorization to proceed, you are acknowledging those terms and conditions.

Our professional service will be performed, our findings obtained and our recommendations prepared in accordance with generally accepted engineering practices. This warranty is in lieu of all other warranties, expressed or implied.

If you agree to authorize this work according to the above outlined scope of work and cost, please have this letter signed by the appropriate authority and return a signed copy to Hart-Crowser & Associates, Inc.

We appreciate the opportunity to submit this proposal and look forward to your favorble consideration. Should you have any questions, please call at your earliest convenience.

Respectfully submitted,

HART-CROWSER & ASSOCIATES, INC.

MATTHEW G. DALTON
Associate Hydrogeologist

TERRY L. OLMSTED
Vice President

MGD/TLO:mw

Enclosures: Figure 1 Proposed Well Location Plan
1983 Fee Schedule
AmTest Letter

APPROVED:

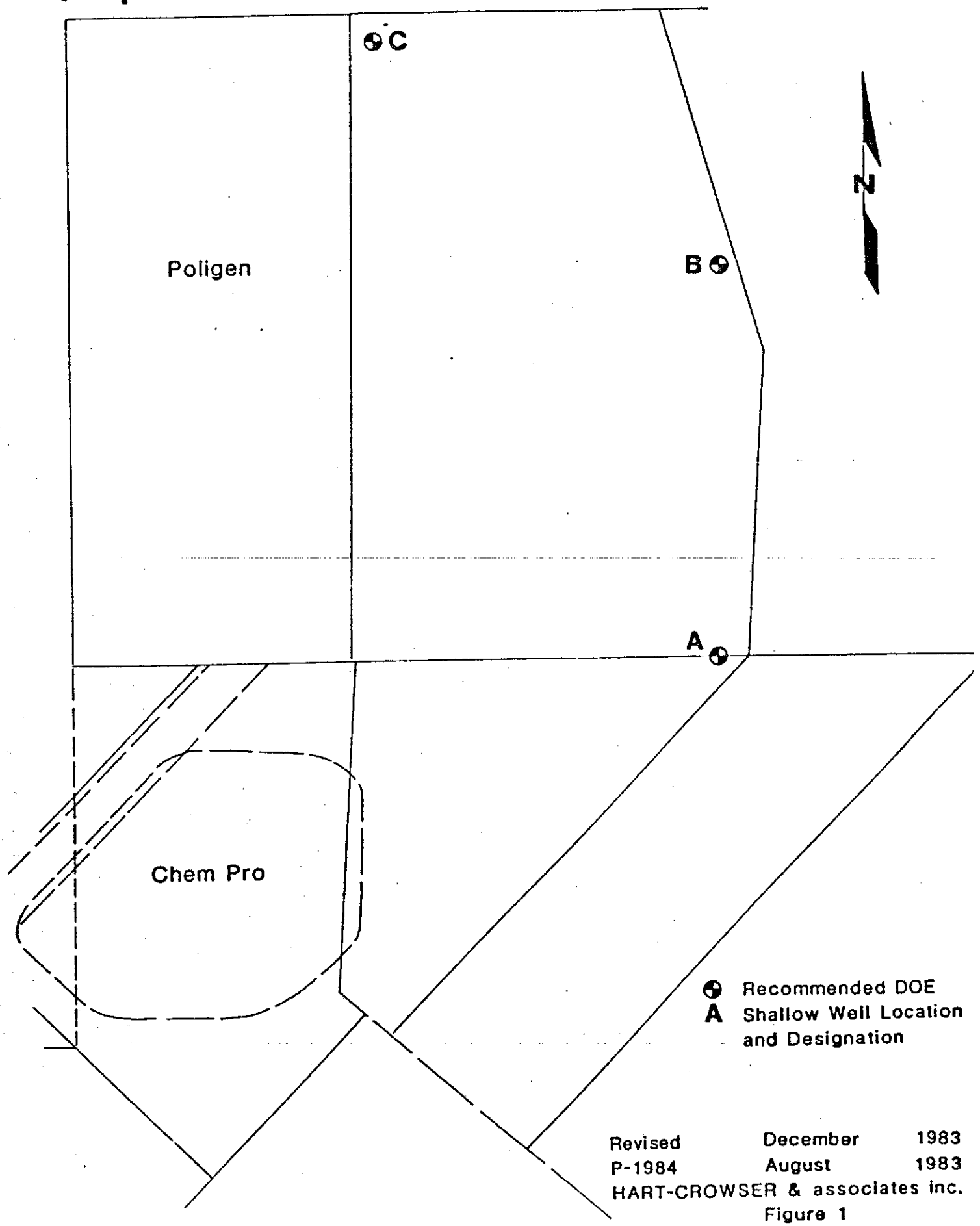
_____
(Signature)

_____
(Name and Title - Please Print)

_____
(Company)

_____
(Date)

Proposed Well Location Plan



Revised December 1983
P-1984 August 1983
HART-CROWSER & associates inc.
Figure 1